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Shearon Harris
Commonwealth Edison
Braidwood 1 & 2
Byron 1 & 2
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Beaver Valley 1 & 2
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Northeast Utilities
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Millstone 3
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OG-00-116
November 15, 2000

WCAP-15604-NP, Rev. 0
Project Number 694

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: Chief, Information Management Branch,
Division of Inspection and Support Programs

Subject: Westinghouse Owners Group
Transmittal of WCAP-15604-NP, Rev. 0, (Non-Proprietary), "Limited Scope High Burnup Lead Test Assemblies" (MUHP-1045)

This letter transmits twelve (12) copies of the report, WCAP-15604-NP, Rev. 0, (Non-Proprietary) entitled "Limited Scope High Burnup Lead Test Assemblies," dated October 2000.

WCAP-15604-NP provides the description of a Limited Scope Lead Test Assembly program and provides the basis for operation of these assemblies to rod burnups greater than the current licensed lead rod average burnup limit. The report provides the process overview of how these assemblies will be analyzed such that they can be justified under 10 CFR 50.59 criteria. The purpose of this report is to provide a means to generate high burnup material characteristic data on an incremental basis to populate the range between the current lead rod average burnup limit and the proposed future limit for fuel which has been operated under both nominal and limiting conditions. These data, along with the results from other industry programs, will be used to set criteria and provide a design basis for requesting future high burnup licensing limits.

The review and approval of this report will provide the means for both PWR and BWR utilities to justify the operation of Limited Scope LTAs on a 10 CFR 50.59 basis. In addition, based on informal discussions with the Staff, WCAP-15604-NP could serve as the basis for the development of a regulatory guide. As such, the WOG hereby requests that all review fees associated with WCAP-15604-NP be waived under the provisions of 10 CFR 170.21, footnote 4, criterion 2 or 3.

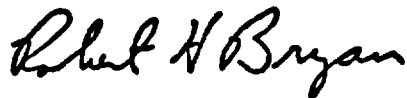
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If you require further information, feel free to contact Mr. Ken Vavrek in the Westinghouse Owners Group Project Office at 412-374-4302.

Very truly yours,



Robert H. Bryan, Chairman
Westinghouse Owners Group

enclosures

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WCAP-15604-NP
Revision 0

Limited Scope High Burnup Lead Test Assemblies

Westinghouse Electric Company LLC
Nuclear Fuel

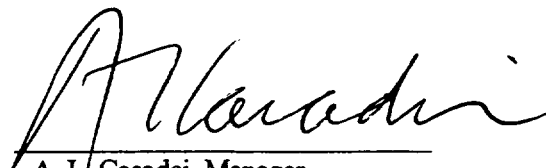


**Limited Scope High Burnup
Lead Test Assemblies
MUHP-1045**

October 2000

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List of Acronyms

The following is a list of acronyms used in this report.

AOA(s)	Axial Offset Anomaly(ies)
BWR	Boiling Water Reactor
ECCS	Emergency Core Cooling System
ID	Inside Diameter
IRI	Incomplete Rod Insertion
ITF	Issue Task Force
LOCA	Loss of Coolant Accident
LTA(s)	Lead Test Assembly(ies)
PIE	Post Irradiation Examination
PWR	Pressurized Water Reactor
RCCA	Rod Control Cluster Assembly
RIA	Reactivity Insertion Accident
SER	Safety Evaluation Report

Executive Summary

This document provides the basis for the operation of a limited number of fuel assemblies to rod burnups greater than the current licensed lead rod average burnup limit and up to 75 GWD/MTU. The basis for the operation of these Limited Scope Lead Test Assemblies (LTAs) is:

- The fuel will be evaluated against and must meet all current design criteria except the burnup limits. Current or modified fuel performance methods and codes will be used even though they may not be licensed to these burnups. This is based on the need to 1) obtain higher burnup data to substantiate the fundamental fuel performance characteristics, and 2) to develop modified fuel performance models (developmental models) to more accurately model the behavior of high burnup fuel.
- The fuel will undergo examinations following operation and the results of those post irradiation examinations (PIEs) will be incorporated into a database and/or developmental models. The data and developmental model performance will be shared with the NRC.
- The fuel will be typical production fuel with no or limited pre-characterization before operation above the current licensed lead rod average burnup limits except where specifically required to show that design criteria will be met. The fuel may also be an LTA, which was characterized during fabrication and was designed to test other aspects of the fuel assembly but was not initially identified as a high burnup LTA.
- The number of fuel assemblies with fuel rods exceeding the current licensed lead rod average burnup limits will be limited to up to a total of thirteen in PWRs and forty-eight in BWRs. Under this program, no fuel rod will exceed peak rod burnups greater than 75 GWD/MTU.

The rationale behind this program is to provide a means to generate data on an incremental basis to populate the range between the current lead rod average burnup limit and proposed future limit from fuel which has been operated under both nominal and limiting conditions (e.g., fuel that has experienced normal or possibly limiting fuel duty). These data along with the results from other industry programs will be used to set criteria and provide a design basis for future operation at burnups above the current licensed limit without the need for cycle specific NRC review or approval.

The review and approval of this report will then provide the means for both PWR and BWR utilities to justify the operation of Limited Scope LTAs on a 10 CFR 50.59 basis.

1.0 Introduction

1.1 Background

Traditionally, a Lead Test Assembly (LTA) is an assembly that is characterized at the fabrication stage and is designed with features that have limited or no in-reactor performance experience. This type of LTA is designed to test the in-reactor performance behavior of various features such as advanced cladding materials, different burnable absorbers, different skeletal components and new mid-grid designs. Many of these design features are typically tested extensively in out-of-reactor environments or in test reactors under atypical operating conditions, but lack the in-reactor commercial reactor experience under normal and limiting conditions.

Another type of LTA is designed to gather data on fuel performance above the current licensed burnup limit. These LTAs are typically based on current production designs and are irradiated to higher than current licensed burnup limits to obtain fuel performance data. The types of data that may be sought include: oxidation behavior, growth behavior, hydriding behavior, fission gas behavior, etc. In the past, as fuel performance data was obtained, it indicated that slight design modifications would be necessary to accommodate the higher burnups that were being sought (e.g., minor changes in the processing and/or chemical make-up of the cladding to better resist corrosion, increased plenum volumes to accommodate increased fission gas release, etc.). As a result, minor design changes have been implemented into the current production designs to accommodate higher burnup and retain high fuel reliability. Data from these LTAs will also provide the basis for improved fuel designs.

In the mid 1990's, new data from international test reactors suggested that the current design criteria that were being used to justify acceptability of fuel designs may not be adequate at the higher burnup levels that were being sought by the industry (see Section 4.1 for further details). As a result, the US-NRC and other international regulators, national and international test laboratories and the industry began a program to investigate whether revised design limits would be necessary for validation of high burnup fuel (e.g., above the current licensed levels). This effort is currently ongoing and the results of this effort will be a set of new design limits that must be satisfied in order to demonstrate acceptability of a particular fuel design to achieve a specified high burnup level. As part of the overall effort, the specified high burnup level will be defined. However, it has been pointed out by the NRC, at recent symposiums⁽¹⁾⁽²⁾, that fuel performance data are needed at all burnup levels above the current licensed limits to justify acceptability of a fuel design and not just data at the maximum limit (e.g., sufficient data is needed to populate a range of burnups to justify the behavior of various parameters).

As a result of the various aspects of the high burnup industry program and the stated need for additional burnup data to demonstrate fuel performance behavior at all burnup levels above the current licensed limit, a proposal to the NRC was made in May 2000. This proposal described a Limited Scope LTA. The Limited Scope LTA, which is defined in the next section, will encourage more LTA programs to be pursued and will result in more data being obtained in the intermediate range of high burnup levels. Thus, when the revised design limits are established and the peak burnup limit is defined, sufficient data will be available to substantiate fuel performance behavior and fuel performance model predictive capability.

1.2 Description of Limited Scope Lead Test Assembly (LTA) Programs

A Limited Scope Lead Test Assembly shall be a fuel assembly based on a currently available design that is capable of reaching burnups beyond that currently licensed. The assembly may receive some limited pre-characterization prior to under-going exposure in the "test" cycle that would permit the assembly to exceed current licensed burnup limits. The fuel assembly shall be analyzed using either currently licensed fuel performance design models and methods or modified developmental versions of these models and shall demonstrate that currently licensed design limits are met for the extended burnup analyzed. However, the models and methods used for evaluation of the limited scope LTAs will not be required to be licensed to the projected burnups, but appropriate conservatism should be included. Limited pre-characterization measurements, if necessary, shall be assessed with the fuel performance design models and methods to ensure that the assembly will not exceed design limits after its final cycle of exposure. An LTA Report, documenting the above analyses to demonstrate acceptability of the LTA, shall be prepared and maintained by the utility/vendor in accordance with 10 CFR 50.59 criteria prior to the "test" cycle. Upon completion of the cycle of exposure, the LTA shall under-go a Post Irradiation Examination (PIE). Post Irradiation Examination of the LTA shall be documented in a PIE report and results of the PIE assessment shall be factored into future analysis to ensure that appropriate conservatisms are being maintained. In addition, tracking of the data results will provide the basis for developmental model creation to more accurately model fuel performance and to capture fuel performance fundamentals. Periodic status updates of the data gathered by the vendor/utility from these programs shall be presented to the NRC. Developmental model performance shall also be tracked against data and presented to the NRC.

1.3 Maximum Number of LTAs per Reload

The maximum number of assemblies that would be considered for a Limited Scope LTA program will vary from utility to utility, based on fuel management studies. However, for the overall Limited Scope LTA Program, the maximum number of LTAs per cycle per core shall be limited to thirteen assemblies for PWRs and forty-eight assemblies for BWRs. The rationale for setting the maximum number of assemblies is based on obtaining a sufficient amount of data while maintaining a high degree of confidence that no safety concerns exist.

Based on current fuel management schemes, the majority of these Limited Scope LTAs are expected to only reach peak rod burnups ranging from the current licensed limit to 68 GWD/MTU with a few obtaining the higher burnups in the range of 68 to 75 GWD/MTU. Since very few assemblies would be achieving the higher burnup levels, it is not anticipated that an unforeseen failure would occur based on experience to date. The most plausible potential failure would be a limited number of fuel rods that may fail due to a specific and limited condition, e.g., excessive oxidation. Since it is not anticipated that any fuel rods would fail in these assemblies due to the fact that they must meet current design criteria even at the higher burnup levels, any single failure that may occur would yield valuable data. If any failures occurred, their effects would be well within the Technical Specification limits for doses and in all cases, core coolable geometry would be maintained.

1.4 LTA Burnup, Duty and Locations

In the past, LTAs were restricted from being placed in limiting core locations. This treatment of LTAs does not yield a representative behavior of the fuel under normal operations. To determine if the LTA meets the need for which it was designed, it must experience the same limiting conditions as other fuel in the reactor and should not be restricted in power or core location except as needed to meet design criteria. The unique aspect of these LTAs is that they are a normal production fuel assembly which will fall into two general categories. These are:

- Fuel assemblies which are reinserted for additional exposure after achieving a burnup where normally they would be discharged so that the burnup limit is not exceeded.
- Fuel assemblies which have normal incore residence times, but are positioned in-core so that the power level results in the burnup limit being exceeded.

The maximum lead rod average burnup that these Limited Scope LTAs would experience is 75 GWD/MTU.

1.5 Licensing Basis

As specified in 10 CFR 50.59 (a)(1)(iii), the holder of a license authorizing operation of a production or utilization facility may "conduct tests or experiments not described in the safety analysis report, without prior Commission approval, unless the proposed change, test or experiment involves a change in the Technical Specifications incorporated in the license or an unreviewed safety question". The use of Limited Scope Lead Test Assemblies (LTAs) does not require Technical Specification changes or result in any unreviewed safety questions. The conclusion that no unreviewed safety question exists will be demonstrated by evaluations showing that the LTAs meets all current licensed design criteria at the anticipated assembly and fuel rod burnup.

The conclusion that the LTAs can be irradiated without prior NRC review and approval (per 10 CFR 50.59) rests on two steps. The acceptance of these steps by the NRC through approval of this report will be necessary to support the analytical justification of the Limited Scope high burnup LTAs. The first step involves an assumption about the use of current fuel design acceptance criteria. The second step is an assessment of the analytical models to be used and modification as necessary.

The first step is the assumption that the current fuel design acceptance criteria can be used to evaluate the performance of the LTAs beyond the current licensed limit. It is anticipated that future work will confirm the validity of most of the current criteria for burnups beyond the current licensed limit. One exception is the deposited enthalpy criteria for design basis reactivity insertion accidents. Currently available data indicates that this criteria may need to be revised. The small number of assemblies involved in these LTA programs, the conservative methods used in the industry to evaluate deposited enthalpy for hypothetical reactivity insertion accidents, and the low deposited enthalpy for high burnup assemblies is sufficient justification to use the current deposited enthalpy criteria for the LTAs.

The second step is the assessment of the models reviewed and approved by the NRC for the purpose of evaluating the performance of the LTAs beyond the current licensed limit. The analytical models used to evaluate the performance of the LTAs beyond the current licensed limit may need to be modified versions of the models reviewed and approved by the NRC. The modification of various models may be necessary to add conservatism to assure the safe operation of the LTAs. Alternatively, the modifications of various models may be necessary to remove excessive conservatism in order to demonstrate compliance with the acceptance criteria. The modifications would be based upon currently available data, data from the pre-characterization activity, or data collected as part of the PIEs for previous Limited Scope high burnup LTAs. If the available data indicates that the approved models are appropriate then no modifications to the approved models would be necessary. The developmental models would only be used for Limited Scope high burnup LTAs. The justification of the model revisions would be documented and available for NRC review in accordance with 10 CFR 50.59 criteria and developmental model performance would be shared with the NRC along with the PIE data results.

2.0 Pre-characterization / Post Irradiation Examination of Data

2.1 Pre-characterization Inspection and Measurement

Pre-characterization is defined here as the measurement of particular fuel performance parameters just before the start of the cycle in which the burnup limits will be exceeded. The need for pre-characterization will be determined based on fuel performance trends and the projected margin. Typically the parameters which would be subject to pre-characterization are fuel rod cladding oxide thickness, fuel assembly and/or fuel rod growth, and guide thimble and/or assembly/channel bow measurements.

The purpose of the pre-characterization is to: 1) obtain data that is useful in understanding the fuel performance based on the known fuel duty, and 2) to ensure that fuel design criteria will not be exceeded in the projected cycle. Pre-characterization of LTAs is intended only as a "go/no go" check against design predictions. Therefore, the data obtained would be significantly less than the data obtained when the Limited Scope LTAs are discharged. As an example, only the most limiting fuel rods may be measured for oxide prior to the final cycle to ensure that sufficient margin exists for the planned cycle of operation.

All pre-characterization checks would be decided upon in advance of the cycle in which the LTA(s) was/were to be inserted and shall be documented in an LTA report. This planning phase for the LTA program would have vendor and utility involvement, including planning of spot checks of an assembly that may be re-inserted. This is also when contingency plans would be made to substitute another assembly in place of the LTA if the spot checks yielded a "no-go" result. The contingency planning is essential to avoiding loading pattern problems just prior to startup.

2.2 Post Irradiation Examinations

The post irradiation examinations (PIEs) are the key inspections/examinations that will provide data for substantiating fuel performance behavior. These inspections/examinations are typically performed off critical path of an outage and therefore extensive measurements can be taken. The vast majority of these inspections are pool side inspections with an occasional hot cell examination done when deemed appropriate by the vendor/utility.

2.2.1 Pool Side Examinations

As noted above, the vast majority of examinations are done pool side. These examinations will provide the majority of data points for the particular fuel characteristics which must be demonstrated to ultimately obtain higher burnup licensing limits. The following sections discuss the various examinations that typically may be performed in a pool side environment. Not all of these examinations would necessarily be required for each LTA program in each plant, but will be based on fuel parameter characteristic needs, fuel duty and operation environmental factors. In addition, the particular measured parameters will vary based on the data needs of the particular vendor and the amount of data accumulated from previous LTA programs. The intent is to obtain sufficient data to substantiate the particular fuel performance criteria of each vendor. As a minimum, each Limited Scope LTA program will measure at least one of the following parameters: cladding oxidation, fuel assembly/fuel rod growth, or channel bow measurements. The most common poolside examinations are listed below.

Oxide Thickness Measurements

The thickness of the ZrO_2 corrosion film on irradiated cladding surfaces and/or structural members is measured. Obtaining the oxide measurements is a check of the corrosion model used in the fuel performance codes and provides a check of the metal-wastage or wall thinning effects.

Cladding Diameter

Profilometry measurements provide an accurate profile of the fuel rod and are used as a means to determine cladding creep behavior and pellet-clad mechanical interaction effects.

Assembly Growth

The axial dimensional stability of fuel assemblies is an important parameter in assessing burnup limits. The fuel assembly predicted growth will be compared to the irradiated measured data to determine how well the irradiation growth model is behaving.

Fuel Rod Growth

The axial gaps between the fuel rod and the assembly top and bottom nozzles are measured during the PIE. The measured irradiated fuel rod growth will be compared to the irradiation growth model.

Guide Thimble Distortion Data

Guide thimble distortion data is obtained and compared to established guidelines which provide indications of possible assembly bow or guide thimble distortion within the fuel assembly.

Assembly Bow

Fuel assembly bow measurements provide a measure of how much assembly distortion has occurred.

Rod-to-Rod Spacing

Rod-to-rod spacing measurements provide a measure of how much individual rod distortion has occurred due to differential rod growth within the fuel assembly.

Guide Thimble ID Oxide Thickness

Guide thimble ID oxide thickness measurements are used to check the structural corrosion model and provides a check of the metal-wastage or wall thinning effects.

Grid Cell Size

Grid cell size measurements are used to check the structural growth model and to assess relaxation rates of grid designs.

Grid Width Measurements

Grid width measurements are obtained to determine in-reactor growth rates of grid material.

Channel Bow Measurements

Channel bow measurements provide a measure of how much assembly distortion has occurred.

3.0 LTA Assessment and Reporting

For each Limited Scope LTA program, the LTA(s) will be assessed to determine if they will meet their specified acceptable fuel design limits and other design criteria and to ensure that they will not result in a deviation of the accident analyses as documented in a plant's FSAR. A summary of the results from this assessment shall be documented in an LTA report which will be the basis, from the technical perspective, to address the 10 CFR 50.59 evaluation.

The following sections discuss fuel assembly, fuel rod, neutronic, thermal-hydraulic and accident analyses aspects of addressing a high burnup Limited Scope LTA. Since each vendor has specific design criteria that have been accepted by the NRC the following discussion demonstrates how one vendor would address the various design and operational aspects of a high burnup Limited Scope LTA. This illustrates the general approach to be taken by all vendors but is not intended to constrain or explicitly specify how other vendors would perform their analyses. Other vendors would necessarily use their own design criteria in place of those provided in this example.

The analytical models used to evaluate the performance of the LTAs beyond the current licensed limit may need to be modified versions of the models reviewed and approved by the NRC. The modification of various models may be necessary to add conservatism to assure the safe operation of the LTAs. Alternatively, the modifications of various models may be necessary to remove excessive conservatism in order to demonstrate compliance with the acceptance criteria. The modifications would be based upon currently available data, data from the pre-characterization activity, or data collected as part of the PIEs from previous Limited Scope high burnup LTAs. If the data indicates that the approved models are appropriate then no modifications to the approved models would be necessary. The modified models would only be used for Limited Scope high burnup LTAs. The justification of the model revisions would be documented and available for NRC review in accordance with 10 CFR 50.59 criteria and developmental model performance would be shared with the NRC along with the PIE data results.

3.1 Mechanical Review

From the mechanical perspective, there are very few specified acceptable fuel design limits or other design criteria that are impacted by high burnup effects. Two key assembly design criteria are discussed as follows: Fuel Assembly and Fuel Rod Growth Allowances, and Fuel Pellet Plenum Spring Solid Height. The fuel assembly and fuel rod growth allowances assure that sufficient space exists within the fuel assembly and core support structures to accommodate the maximum expected fuel rod and fuel assembly growth without axial interference. The fuel pellet plenum spring solid height requirement

ensures that the plenum spring will not go solid during fuel rod operation and prevent free expansion of the fuel pellets. These evaluations would be checked and documented in the LTA report.

3.2 Neutronic Review

The evaluation of Limited Scope LTAs from the neutronic standpoint is not much different than that for currently licensed fuel products up to the current licensed lead rod average burnup limit. The effects of burnup on neutronics analyses up to the current licensed lead rod average burnup limit are discussed in vendor or utility specific proprietary topical reports. These reports typically show that the neutronic models are acceptable up to the current licensed lead rod average burnup limit based on comparison to surveillance data which is typically an SER requirement for acceptance of these models. Based on experience with other high burnup LTAs, these models are expected to yield acceptable results for burnups up to 75 GWD/MTU. Again, surveillance data of the core performance will be compared to predictions to demonstrate acceptability.

3.3 Thermal-Hydraulic Review

High burnup effects do not impact any of the thermal-hydraulic design criteria for a specific fuel product. Therefore, the Limited Scope LTAs will be evaluated along with the other fuel assemblies for acceptability from a reload standpoint.

3.4 Fuel Rod Design Review

Fuel rod design criteria are specified in the Standard Review Plan, Section 4.2 and assure that fuel system dimensions remain within operational tolerances and that functional capabilities are not reduced below those assumed in the safety analysis. Each vendor has specific fuel rod design criteria reviewed and approved by the NRC. The criteria noted below may not apply to all vendors, but are provided as a sample of what would need to be justified for a Limited Scope LTA program by one vendor. The currently licensed specific limits are specified in the proprietary topical reports submitted by the vendor and are not specified herein.

- | | |
|--------------------------------|---------------------|
| • Fuel Rod Internal Pressure | • Fuel Rod Growth |
| • Clad Stress and Strain | • Fuel Temperature |
| • Clad Oxidation and Hydriding | • Clad Fatigue |
| • Plenum Collapse | • Clad Freestanding |
| • Clad Flattening | |

For a Limited Scope LTA, only a few of these criteria would be limiting at the higher burnups. The evaluations of these criteria would be documented in the LTA report.

3.5 Safety Assessments

3.5.1 Non-LOCA Accidents

Since the Limited Scope LTA(s) would be analyzed as part of the reload design and must meet the current design limits, the Limited Scope LTA(s) would be covered by the Chapter 14/15 analysis of record. With regards to non-LOCA accident analyses, the one Chapter 14/15 analysis that is typically limiting and is considered the most severe of the reactivity initiated events is the rod ejection (PWR)/rod drop (BWR) accident. This event has received considerable interest as noted in Section 4.1. However, it was concluded that even if these events were to occur, the radiological consequences would be well within the NRC requirements for the event, even if it was conservatively assumed that high burnup fuel in the core would fail at extremely low levels of energy deposition.

3.5.2 LOCA Accidents

The Loss Of Coolant Accident (LOCA) is governed by 10 CFR 50.46 Acceptance Criteria. These criteria state that:

- The calculated maximum fuel element cladding temperature shall not exceed 2200 °F.
- The calculated total oxidation of the cladding shall nowhere exceed 0.17 times the total cladding thickness before oxidation.
- The calculated total amount of hydrogen generated from the chemical reaction of the cladding with water or steam shall not exceed 0.01 times the hypothetical amount that would be generated if all of the metal in the cladding cylinders surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react.
- Calculated changes in core geometry shall be such that the core remains amenable to cooling.
- After any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactivity remaining in the core.

These acceptance criteria are shown to be valid for the normal reload fuel in the core. Therefore, only those aspects of inserting Limited Scope LTAs need to be addressed. The two acceptance criteria that could be impacted by Limited Scope LTAs are: 1) the 2200 °F peak cladding temperature acceptance

criterion, and 2) the total localized oxidation acceptance criterion of 17%. These evaluations would be checked and documented in the LTA report.

3.5.3 Radiological

There are two areas that will be discussed from a radiological standpoint as they will relate to the Limited Scope LTA(s): 1) the effect of high burnups on source terms and associated dose calculations and 2) the radiological consequences of an RIA for the rod ejection/drop accident.

The effects of high burnups on source terms and the associated doses have been discussed⁽⁴⁾ in the past. One vendor's evaluations⁽⁴⁾ discussed the impacts of extended fuel burnup level on source terms, gap fractions, normal operating plant releases, and accident doses. These evaluations addressed fuel burnup levels up to 75 GWD/MTU. Based on these previous evaluations, the use of Limited Scope LTAs would not result in an increased risk of radiological consequences on a reload basis.

With regards to the radiological consequences of an RIA for the rod ejection event, this evaluation has been addressed in Reference 3 and will not be repeated herein.

4.0 Addressing Industry Issues

In considering the acceptability of high burnup Limited Scope LTAs, there are several current industry issues associated with fuel that the NRC has requested be addressed. These issues are Reactivity Insertion Accidents (RIAs), higher oxidation than predicted, excessive rod internal gas pressure at end-of-life, incomplete RCCA insertion (IRI), breakaway/accelerated growth of fuel rods and assemblies, fuel failures due to high fuel duty, high crud build-up, Axial Offset Anomalies (AOA), and adverse effects of water chemistry. Several of these issues are inter-related and will be briefly discussed based on their inter-relationship. The following discussions are an example of how one vendor has addressed these issues.

4.1 RIAs

In November 1994, the NRC requested that the fuel vendors review their previously approved topical reports to assess if these topical reports remain appropriate in light of the unexpectedly low failure threshold seen in the CABRI Reactivity Insertion Accidents (RIA) test results. Each vendor provided a response to the NRC request.

In Reference 3, the Industry Issues Task Force (ITF) provided to the NRC information detailing the safety significance assessment with respect to the potential reduction in failure threshold for high burnup fuel during postulated RIA. Reference 3 concluded that the probability of an RIA occurring was extremely small (10^{-4} to 10^{-6} per year). It was further concluded that even if these events were to occur, the radiological consequences would be well within the NRC requirements for the event, even if it was conservatively assumed that high burnup fuel in the core would fail at extremely low levels of energy deposition.

4.2 Excessive Rod Internal Gas Pressure and Increased Oxidation

In 1996, surveillance data on cladding oxidation indicated that the current corrosion model used by a vendor may under predict the observed corrosion seen in the field. In December 1996, the vendor introduced a new corrosion model that was demonstrated to be conservative and to bound the most recent surveillance data. When the new corrosion model was incorporated into the fuel performance model, the feedback effects of the increased corrosion resulted in "predicted" gap re-opening situations in some reload designs. Although the "predicted" gap re-opening issue was generally conservative, and subsequent model changes licensed through the NRC have mitigated this issue, the effect of the increased corrosion on rod internal pressure is real.

Based on design changes made to the fuel to regain rod internal pressure margins and a newly licensed fuel performance model, it is not expected that the Limited Scope LTAs would be susceptible to these issues. As part of the evaluations that would be performed for the Limited Scope LTAs, a corrosion and a rod internal pressure analysis would be required. If a Limited Scope LTA was projected to fall into a gap re-opening or excessive corrosion situation, it would not be permitted to be used.

4.3 Incomplete RCCA Insertion and Breakaway/Accelerated Growth

Incomplete RCCA Insertion (IRI) has occurred in the recent past. Root cause investigations have been initiated to determine the fundamental cause of this issue. There have been several root causes associated with this issue, one of which is breakaway/accelerated axial growth occurring within the fuel assembly skeleton. However, not all fuel assembly designs have shown susceptibility to IRI, and for those fuel assembly designs that have experienced IRI, numerous corrective actions have been implemented to resolve this issue. Due to the nature of this issue, each fuel vendor would need to determine the susceptibility of their fuel assembly designs to IRI. This assessment would be used to evaluate the susceptibility of assemblies to be used for the Limited Scope LTA program. The evaluation would be documented in the LTA report for each Limited Scope LTA program.

4.4 High Crud Build-up, AOA, Adverse Water Chemistry and High Fuel Duty Fuel Failures

High crud build-up, adverse water chemistry, high fuel duty and AOA have been determined to be inter-related. Some plants operating under these more demanding conditions have experienced increased crud deposition and AOA. A root cause investigation of AOA has determined that as the crud builds-up on high-power rods, boron from the primary coolant chemistry deposits within the crud matrix. The boron deposited in the crud can result in the axial offset anomaly (AOA). As the fuel reaches higher burnup levels, it no longer operates at the high power levels at which susceptibility to AOA has been observed. Since at high burnup, the Limited Scope LTAs will not operate at high power levels, they would not be susceptible to AOA. Assemblies that have unusual or high levels of corrosion as a result of having experienced AOA earlier in life will not be included in a Limited Scope LTA program if it is estimated that the additional exposure may lead to exceeding the corrosion design criterion.

In some cases excessive crud deposition on high-duty fuel has led to accelerated corrosion and failures. The Limited Scope LTAs will be at burnups where their fuel temperatures will be reduced and crud accelerated corrosion will not be a concern. Assemblies that have experienced crud-induced accelerated corrosion will not be included in a Limited Scope LTA program if it is estimated that the additional exposure may lead to exceeding the corrosion design criterion.

5.0 Feedback Mechanism for Future Design / Model Changes

The data obtained from the PIEs, conducted on the Limited Scope LTAs, will be used to evaluate the criteria, models and methods used in fuel rod design as well as to confirm the performance margins for individual fuel designs. Based on data trends observed, fuel design changes may be required to accommodate high burnup limits. The data trends may also identify changes to operational conditions that may be required to support the higher burnup limits. In addition, new models, criteria or methods may be required depending upon how the data trends with current models and methods. Typically, the data obtained from an individual PIE campaign is compared against the existing database to ensure that operation of additional Limited Scope LTAs will not result in design criteria being exceeded. It is also important to correlate the detailed operations data of fuel duty, temperature, chemistry, etc. with the observed fuel performance measurements that are obtained from these programs.

6.0 References

1. Chatterton, Margaret S. (NRC), "Regulatory Perspectives on High Burnup Fuel Issues and Burnup Extension," ICONE 8 Conference, Baltimore, MD, April 2-6, 2000.
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3. Letter from Marion, A. (NEI) to R. Jones (NRC), "NEI Response to NRC Staff's Request for Information on Reactivity Insertion Accidents," December 28, 1994.
4. Davidson, S. L. (Ed.), et al., "VANTAGE + Fuel Assembly Reference Core Report," WCAP-14342-A (Non-Proprietary), April 1995.